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Heavy metal concentrations in Helobdella stagnalis were found at all sites during the collecting period. An inventory of benthic organisms present in six regions of the St. Louis River during the spring, summer and fall of 1975 is included.

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STATIC COAL STORAGE--BIOLOGICAL EFFECTS ON THE AQUATIC ENVIRONMENT

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FOREWORD

Attempts to predict the environmental impacts of greatly increased utilization of western coal clarified the need for data on the effects of each segment of the total coal-based fuel cycle, from the mine through transport, storage and conversion to electrical energy. In order to partially meet the need, a study was made ofthe environmental effects of the storage of western coal in large open-air holding piles in a transshipment facility located in the Superior, Wisconsin - Duluth, Minnesota harbor area.

This report presents the results of studies of the amounts of metals leached from a western and an eastern coal and the effects of these metals on several aquatic plant and invertebrate organisms.

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ABSTRACT

Benthic samples taken from four regions of the ORBA Coal dock facility indicated that the aquatic environment was moderately polluted as indicated by the kinds of benthic species present and by the diversity index value. An efficient rearing technique for benthic organisms results in low mortality. The life cycle from hatching to pupal formation in the *Chironomus sp.* takes 21.9 days at 20.5°C. Stress factors and swimming behavior are also discussed.

Heavy metal concentrations in *Helobdella stagnalis* were found at all sites during the collecting period. An inventory of benthic organisms present in six regions of the St. Louis River during the spring, summer and fall of 1975 is included.

B. BENTHOS

1. Introduction

The study of benthos is concerned with substrate organisms, both plant and animal, that live in or on the bottom of a body of water. In the St. Louis River, these organisms are important in the ecosystem as sources of food either directly or indirectly for higher organisms such as fish, birds and man (Anderson and Smith, 1971). Thus, the stability and the functioning of this portion of the ecosystem has far ranging effects upon a variety of organisms. Certain substances may accumulate either temporarily or permanently in these organisms. Later these substances may be found stored in higher members of the food chain of the animal kingdom at an increased level because of the high number of organisms eaten as food by higher level consumers. The increased concentration of certain substances, which can in some cases reach many thousand fold over the concentration originally found in the waterway, may interfere with normal physiological functions within the higher level consumers. Therefore, it is becoming increasingly apparent that the chain of events leading from benthic organisms to the highest member of the food chain needs to be further investigated in greater detail. This study identifies the benthic organisms which will be exposed to material leached from coal or coal dust as a result of storage close to a water system. It also shows concentrations of heavy metals found in some of the benthic organisms, and it describes how some benthic organisms can be reared under laboratory conditions so that future laboratory controlled experiments can be performed. Also described are various aspects of the natural history of the benthic organisms which were kept in culture.

2. Methods

Field Sampling Techniques--

The biological research group at the University of Wisconsin-Superior sampled four areas in the region of the ORBA Coal Dock facility and two areas of the existing Riess Coal Dock three times during 1975. The sampling dates were July 9, August 9 and September 29, 1975. All benthic samples were collected with a 23 cm x 23 cm Ponar dredge. Three samples were taken from each of the six areas. The three replicate sites were generally within 50 yards of each other and were visually selected to represent the general conditions found within the area. All samples were placed in five quart plastic containers and frozen immediately upon return to the laboratory. These samples were kept frozen until sieving. At that time the organisms were sieved with a 30 mesh screen and preserved in 70% ethyl alcohol until they were identified. Identification of organisms to species, where possible, was accomplished with a dissecting microscope and the following keys: Burch, 1972 and 1973; Mason, 1973; Edmondson, 1959; Pennak, 1953; Eddy and Hodson, 1961; Needham and Needham, 1962; Williams, 1972; Klemm, 1972; Brown, 1972; and Holsinger, 1972.

Laboratory Rearing--

The initial stock organisms of *Chironomus* sp. were collected from the substrate in the St. Louis River July 21, 1975. These organisms were transported to the laboratory in five quart containers and here the Chironomids freed themselves from the substrate and entered the water column. These orga-

nisms were then transferred to the rearing chambers with a wide apparatus eye dropper.

Rearing Chambers--

The rearing chambers were 3" x 8" culture dishes in which a hole 20 mm in diameter was drilled one inch from the top and was fitted with a #3 one-hole neoprene stopper in which was inserted an 8" L-shaped glass tube (see Figure IV-B-1). This tube formed an outlet to the rearing chamber. The end of the tube which protruded into the rearing chamber was lightly fitted with glass wool to prevent culture organisms from escaping. Recirculated water passed through this outlet tube and into a five gallon aquarium which was located directly beneath (Figure IV-B-1). This aquarium held the bulk of the recirculated water used for the rearings.

Water entered the rearing chamber by being elevated from the five gallon aquarium mentioned above by a continuous stream of air bubbles passing through a 10" culture dish inlet tube. The temperature of the incoming water could be regulated by controlling the rate of air flow through the inlet tube by adjusting the air valve. A temperature of 20.5 ± 0.5°C (monitored by a continuous recording thermometer) was maintained for all chironomid colonies. Water used for the rearings was Lake Superior water obtained from the Environmental Research Laboratory, Duluth, Minnesota.

Temperature Control Tank--

To control the temperature of water in the five gallon aquarium which influenced the temperature in the culture dishes, the five gallon aquaria were placed in a thirty gallon aquarium tank which had connections to hot and cold water (not shown in Figure IV-B-1). By regulating the flow of water from each tap a uniform (± 1°C) temperature could be maintained both during the summer and winter months.

Chironomus sp.--

Egg Stage--Eggs were deposited by the female at the surface of the water in a gelatinous mass with a varied egg pattern. Some contained a single strand of eggs evenly deposited in a spring-like coil and some had a more random egg pattern. The number of eggs laid varied among the females but usually the number was between 100-350. Based on ten colonies reared at 20.5 ± 1°C, it takes 5.1 days to hatch.

Larva Stage--Soon after hatching the larvae began to build tubes which were open at both ends and in which the larvae spent the majority of their larval and pupal life. As the larvae grew material was added to this tube to compensate for the increase in body size. In nature this tube is usually built of algae, fine silt and small sand grains but in the laboratory without extraneous material the tube was constructed mostly of fecal material.

Growth from the time of hatching to pupal formation based on ten colonies took 21.9 days. The first day after hatching the larval length ranged from 1 mm to 1-1/2 mm; the third day from 3 to 6 mm; the seventh day 5 to 8 mm; the ninth day 8 to 10 mm; the twelfth day 10 to 15 mm; the sixteenth day from 10 to 20 mm. Because much of the larval life is spent inside their tubes it is difficult to predict with certainty the number of larval instars. However,

it was predicted, by indirect means, to be approximately six. Because of the range in size throughout the growth period, the size difference appears to be a result of dimorphic differences among the larvae. The size may be the difference between future males and females. This accounted for the size difference among larvae of the evergreen bagworm, *Thyridopteryx ephemeraeformis* (Morden, unpublished data) which also had a case which enclosed the larvae.

Laboratory stress factors can influence the rate of growth of the larvae. One factor was stagnation. Several attempts were made to rear the larvae using two quart non-circulating rearing chambers. In all cases the chironomids failed to complete one life cycle with most colonies failing to grow past the fourth instar.

Another factor was diet. The food fed to the larvae influenced the growth rate as well as their general vitality. Two kinds of food were fed to the larvae. The chironomids were able to complete a life cycle using either Red Star® instant blend active dry yeast or Tetramin® staple food, a widely distributed tropical fish food. However, there was slower growth and higher mortality when yeast was used. The data on life cycles were based on colonies which were fed Tetramin®. This food was placed in the rearing chamber each day. The amount fed was just what the colony would consume in thirty minutes.

Larvae in the fourth instar were transferred to tap water. Activity soon became slower and the colony failed to survive beyond the fourth day in the tap water even though food was supplied. This may have resulted from chlorine found in tap water.

Water from a well which was drilled on campus during the fall of 1975 was used and the chironomids were able to complete a life cycle although mortality was higher than when Lake Superior water was used. Mortality in this colony approached 90% compared to the 10% reared under optional conditions. This well water was later tested and found to be high in salts.

The hemoglobin pigment found in some Chironomids is red and the presence in the insect can be observed by visual inspection. During the first instar no red pigment can be seen. During the second instar the larvae change from pink to red and by the third instar the larval blood appears to be fully hemaglobinized.

The larvae swim by an interesting twisting motion of one part of its body on another. Following a "S" shaped pattern, the posterior end of the larvae curls up in a twisting motion and passes over the head. As this happens the anterior half of the body flips quickly downward giving the "lift" necessary for swimming.

When healthy larvae are not swimming they remain in their tubes with the anterior half of the body extending from the tube and swaying back and forth. This motion may aid the larvae in obtaining oxygen by permitting more water to pass over the body surface. This motion in clearer water, however, may attract fish and thus would not be as beneficial to the chironomid.

Pupa Stage--The pupa stage, based on ten colonies at 20.5 ± 1°C, lasts for

2.1 days. When the larvae change to the pupa stage, the head capsule become larger and more defined and possess two small white tufts. The pupae are less active than the larvae but retain some motility as they can tumble through the water. The size of the head capsule in relation to the body becomes noticeably greater when the larvae change to the pupal stage.

Just before pupation the larvae closes the ends of its tube and then develops to the pupa stage. However, it is not necessary to change within the tube as some successfully completed the transformation in the laboratory outside the tube. Just before the adult emerges from the pupal case, the pupa is found at the surface of the water.

Adult Stage--The adult emerges from the pupal skin by pulling itself out through the split in the thoracic segments and then flies away. Based on ten colonies, the time from this moment until the first eggs are deposited is 5.4 days.

The females are easily distinguished from the males by the antennae. The males' antennae are feathery or plumose while the females' antennae are simple and stylate.

The total duration from egg stage through egg stage based on the ten colonies at 20.5 ± 1°C was 32.4 days. The percent mortality of the colonies from the egg stage to the adult stage was approximately 10%.

3. Results

Benthic Indicator Organisms--

Indicator organisms are used to provide a relatively fast and easy means by which the environmental quality of an area can be classified.

The following benthic organisms normally do not tolerate toxic pollution. Also given is the location and time of year when collected. *Physa* snails were found at site six (The C. Reiss Coal Company site) during the spring sampling. Sphaerid clams were generally found in the shallow sites during the entire collecting season. Red chironomids were usually present in all areas sampled during all collecting periods. Other organisms found within the collecting area which are susceptible to lead, zinc, and copper were worms, leeches, *Asellus* and molluscs (Thomas, Wilcox and Goldstein, 1976).

Diversity Index--

A more stable and predictive assessment of environmental stability and water quality is the concept of species diversity. Its shortcoming is the inability to reflect accurately the biomass and the individual species present.

Because of the uniform size of the samples taken from each collecting site the following equation was used to calculate the diversity index (D.I.).

$$D.I. = \frac{N^2}{\Sigma n_1^2 + n_2^2 + n_3^2 \ldots n_x^2}$$ Kaill and Frey, 1973

The total number of organisms collected from a site is squared (N^2) and this number is divided by the sum of the squares of each species (n^2). A higher number reflects a greater diversity among the species, and this usually indicates greater species interaction and greater ecological stability.

Using the above formula, values close to 10 indicate clean water and a stable environment. Values close to 1 indicate that the number of species interaction is generally reduced while intermediate values indicate a moderate degree of interaction and stability.

All sites sampled in this study indicate little species interaction. However, one site was clearly more stable than the others during all sampling periods. This was site six, a shallow, coal-rich area found at C. Reiss Coal Company site (see Tables IV-B-4 through IV-B-6).

Diversity Index Relationships--

t-Test--Because the data was symmetrically matched by site location during the collecting period a t-test (McCall, 1975) was performed on the D.I. to see if any significant differences existed among the spring samples, the summer samples and the fall samples. This analysis should show changing degrees of species interactions among the sites during the collecting period.

As seen from Table IV-B-1, the greatest difference observed was between the summer sampling and fall sampling; however, the assumption that a change occurred can be made with only 29% certainty. There was no significant change between spring and summer samples. Therefore, the change in the relative stability of the environment among the sites during the seasonal period of active growth for organisms is at most extremely slight.

Correlation Analysis--

A correlation using the D.I. was performed on the data to see if community stability was different among the sites when comparing shallow and channel depths and between coal and non-coal environments.

From Table IV-B-2 the t values exceed the critical values at the .05 level with seven degrees (n-2) of freedom. Therefore, a significant difference does exist at the .05 level. There is a greater diversity found in coal areas than non-coal areas and there is greater diversity in shallow areas compared to channel depths.

Heavy Metal Concentrations--

The heavy metals examined in the laboratory were found in *Helobdella stagnalis* which was sampled from all sites during the collecting period.

The test organisms were collected during 1975, identified in the laboratory and stored in 70% ethyl alcohol. Samples were later dried in a vacuum oven for 5 hrs at 70°C. If not used immediately samples were stored in a desiccator. Sample weights were determined, then organisms were placed in Parr bomb and digested. Approximately 2 ml of ultrapure nitric acid was used for each digestion. The digested samples were then diluted to a predetermined volume (m-1 through m-8 to 20 ml) and analyzed by atomic absorption methods. Results are found in Table IV-B-3. For methods refer to Section V-B-7.

To obtain enough weight per sample to be analyzed, leeches from different sites had to be combined. Thus heavy metal information about some individual sites was lost. However, some sites were not combined. Organisms from different collecting times were never mixed.

Background levels of heavy metals found in the sediments where benthic organisms were taken are not available as a result of a laboratory oversight. However, concentrations of heavy metals present in Lake Superior water are given in Table IV-B-3. For procedures refer to Section V-B-7.

Table IV-B-3 indicates that heavy metals are sequestered by benthic organisms. Exceptionally high values of copper and lead were found in organisms collected during July from the dredged channel at C. Reiss Coal Company dock. An analyzed environmental sample from this area might help explain these high levels.

4. Discussion

One species of Chironomidae was successfully reared under laboratory controlled conditions. This organism could be used as an invaluable aid for determining environmental stress. Because of its noted sensitivity to changing rearing conditions, it could be used to determine the precise effects of coal material or other material on its life cycle and physiology. This is the direction that future studies of environmental stress on aquatic organisms should follow.

The kinds of species of benthic organisms found in the study area suggest that the water is moderately polluted (Cairns and Dickson, 1973) yet contains low levels of toxic heavy metals.

Heavy metals are apparently sequestered by the leech, *Helabdella stagnalis*. This organism is a member of the food chain leading through fish to man. Heavy metals are sequestered by benthic organisms. If these organisms with concentrated levels of toxic material are consumed in large amounts by higher level consumers and the metals further concentrated by top level consumers, then there is reason for concern - especially if man is the highest level consumer.

Although coal appears not to be harmful to the aquatic system and in fact may be correlated with environmental stability, we must not lose sight of the fact that certain metals released either from coal or from other sources are concentrated in organisms at every level in the food chain. Thus low level concentrations of certain materials may be tolerated by organisms occupying a low level in a food chain, but these metals may be concentrated through the food chain and may become so toxic in higher level consumers that pathological conditions develop.

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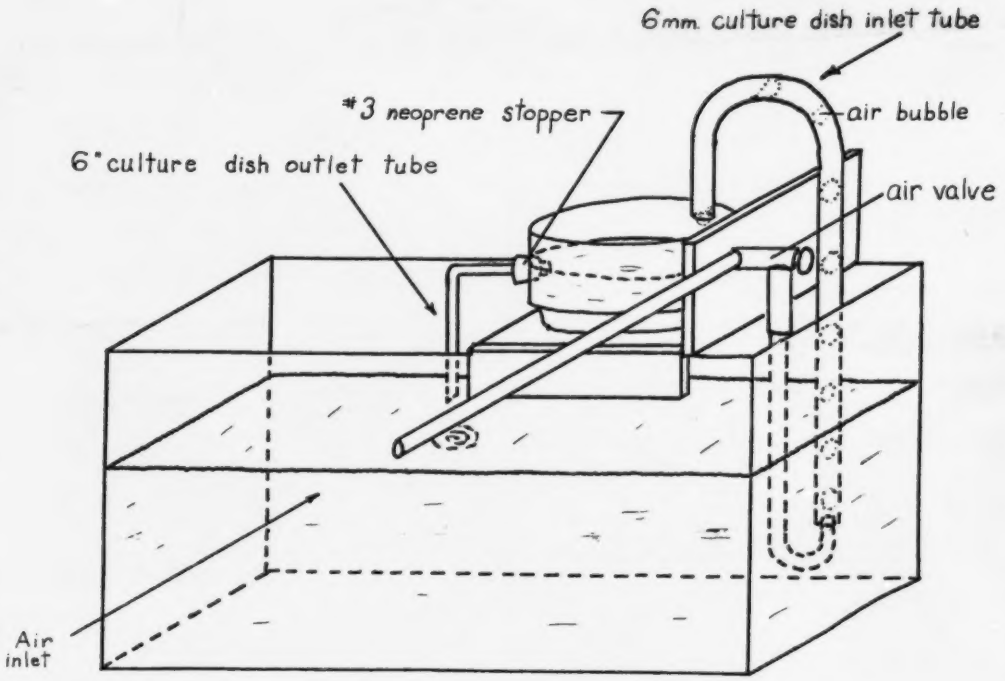

Figure IV-B1. Chironomid Rearing Chamber.

TABLE IV-B-1

Significance of the Difference in the Diversity Indices

as Related to Seasonal Collecting Times

	t Score*
Spring Sampling vs. Summer Sampling	0.009
Summer Sampling vs. Fall Sampling	0.29
Spring Sampling vs. Fall Sampling	0.24

*Calculated from the equation: $\sigma md = \frac{\sigma \text{ diff.}}{\sqrt{n-1}}$

σmd = standard error of the mean difference

$\overline{X}$ diff. = mean of the difference data

σ diff. = standard deviation of the difference data

McCall, R. B., 1975.

TABLE IV-B-2

Correlation and Significance of Site Variations With Sampling Depth and Between Coal Areas and Non-Coal Areas Using Diversity Indices

	Coefficient of Correlation* r_{xy}	Significance of the Correlation Coefficient t Value**
Shallow Site vs. Channel Site	-0.19	.512
Coal Areas vs. Non-Coal Areas	0.29	.802

* Values calculated from the equation: $$r_{xy} = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

**Values calculated from the equation: $$t = r_{obs} \frac{\sqrt{N-2}}{\sqrt{1-r_{obs}^2}}$$ with df = N-2

McCall, R. B. 1975.

TABLE IV-B-3

Concentration of Metal in Organisms (ppm) Dry Weight

Sample		As	Ba	Cd	Cr	Co	Cu	Pb	Mn	Mo	Se	V	Zn
Helobdella stagnalis													
M-1		6.7	360	3.3	8.0	3.3	110	22	190	<0.7	<6.7	<3.3	1270
M-2		5.1	70	3.1	5.1	2.3	695	665	275	<0.3	<2.6	<1.3	1570
M-3		<2.1	60	2.1	1.7	1.7	45	3.[illegible]	145	<0.2	<2.1	<1.1	700
M-4		<4.2	225	0.9	4.7	1.3	45	3.5	195	<0.4	<4.2	<2.1	780
M-5		6.9	95	1.4	5.8	2.1	140	23	220	<0.3	<3.4	<1.7	400
M-6		3.7	129	1.1	3.3	1.9	180	7.0	110	<0.4	<3.7	<1.9	140
M-7		<1.7	75	2.2	1.0	0.8	50	6.9	185	<0.2	<1.7	<0.8	400
M-8		2.9	135	8.7	6.7	1.4	180	27	145	<0.3	<2.9	<1.4	580
M-A-9	laboratory amphipods	<1.9	190	0.6	1.7	0.6	40	0.8	40	0.2	<1.9	<0.9	55
M-I-10	laboratory isopods	4.1	75	2.1	2.9	1.0	265	2.9	110	0.2	<2.1	<1.0	90
Background concentration of liquid preservation 70% ethyl alchol		0.0	0.0	0.2	0.4	0.0	1.1	0.7	0.7	0.0	1.0	0.0	0.7

Concentration of Metal in Lake Water (ppb)

Sample	As	Ba	Cd	Cr	Co	Cu	Pb	Mn	Mo	Se	V	Zn
Lake Water	2	37	0.6	0.3	0.9	34	1.9	4.9	1.1	<1	<1	5.5

TABLE IV-B-4

Benthic Organisms of the St. Louis River, 9 July 1975

PHYLA	GENUS	SPECIES	1-A	1-B	1-C	2-A	2-B	2-C	3-A	3-B	3-C
Nemathelmenthes Nematoda			2	1		86		2	19	17	
Annelida	Marvinmeyer	lucida		1							
	Helobdella	elongata		3	9	4		13	2		3
	Helobdella	stagnalis			3	2		1	4	8	4
	Myzodella	moorei					1	1			
	Illinobdella	alba									
Mollusca	Sphaerium	transversum	1	1							
	Sphaerium	simile									
	Sphaerium	lacustre		3							
	Sphaerium	nitidum							22		
	Sphaerium	securis	3			2					
	Sphaerium	partumium									
	Sphaerium	rhomboideum									
	Sphaerium	fabale									
	Sphaerium	striatinum		1							
immature or damaged clams	Sphaerium	occidentale	1			3	2	2	1	2	1
	Promentus	exacuous megas									
	Gyraulus	deflectus									
	Helisoma	anceps anceps									
	Promentus	unbilicatellus									
	Marstonia	decepta									
	Amnicola	limnosa		7							
	Valvata	sincera			1						
	Valvata	tricarinata		1	3						
	Pisidium	fallax									
immature or damaged snails											
	Eupera	cubensis	1								
	Ferrissia	rivularis		1							
	Planorbidae	(immature)		4							
	Pisidium	dubium				1					
	Pisidium	ventrosum								1	
	Pisidium	idahoensi									
	Physa	jennessi									
DIVERSITY INDICES (D.I.)			4.84	3.88	4.43	1.84	1.32	3.01	3.41	2.45	2.02

TABLE IV-B-4, Continued

Benthic Organisms of the St. Louis River, 9 July 1975

PHYLA	GENUS	SPECIES	4-A	4-B	4-C	5-A	5-B	5-C	6-A	6-B	6-C
Nemathelmenthes Nematoda						4	13	8			
Annelida	Marvinmeyer	lucida					1	18	2		
	Helobdella	elongata					1	10			
	Helobdella	stagnalis									
	Myzodella	moorei					10				
	Illinobdella	alba									
Mollusca	Sphaerium	transversum	6	2	1				1		
	Sphaerium	simile		1							
	Sphaerium	lacustre		1	6				10	7	2
	Sphaerium	nitidum		1	1						
	Sphaerium	securis							1		6
	Sphaerium	partumium									
	Sphaerium	rhomboideum									
	Sphaerium	fabale									
	Sphaerium	striatinum									
	Sphaerium	occidentale									
immature or damaged clams					4		2		4	5	1
	Promentus	exacuous megas									
	Gyraulus	deflectus									
	Helisoma	anceps anceps									
	Promentus	umbilicatellus								1	
	Marstonia	decepta									
	Amnicola	limnosa									
	Valvata	sincera								2	
	Valvata	tricarinata							9		1
	Pisidium	fallax									
immature or damaged snails									1		
	Eupera	cubensis							2		
	Ferrissia	rivularis									
	Planorbidae	(immature)									
	Pisidium	dubium									
	Pisidium	ventrosum									
	Pisidium	idahoensi			2					1	
	Physa	jennessi									
DIVERSITY INDICES (D.I.)			1.57	2.32	2.60	1.47	3.80	4.19	5.11	5.73	4.57

TABLE IV-B-4, Continued

Benthic Organisms of the St. Louis River, 9 July 1975

PHYLA		GENUS	SPECIES	1-A	1-B	1-C	2-A	2-B	2-C	3-A	3-B	3-C
Arthropoda		Gammarus	fasciatus		1	1						
		Gammarus	lacustris		4	2				1		
		Gammarus	pseudolimnaeus		1							
		Hyallella	azteca									
		Pontoporia	affinis									
		Asellus	intermedius		27	6		1	3		3	
		Asellus	racovitzai									
		Rheotanytarsus	sp.									
		Tribelas	sp.									
		Cricoptopus	sp.									
		Lauterborniella	sp.									
		Procladius	sp.	3			23	33	24	34	52	24
		Parachironomus	sp.		1							
		Cryptochironomus	sp.					1	1		4	2
		Chironomus	sp.						1			
		Polypedilum	sp.									
		Coelotanypus	sp.									
		Potthastia	sp.									
		Paracladopelma										
		Podonominae	sp.									
	Tricoptera	Glossosoma	sp.									
	Tricoptera	Phylocentropus	sp.									
	Tricoptera	Neureclipis	sp.									
	Tricoptera	Molanna	sp.									
		Leptocella	sp.									
Insecta		Corixidae Nymph	sp.									
Insecta		Plecoptera Nymph	sp.									
		Hexagenia	sp.									
		Wormaldia	sp.									
	Cladocera	Eurycercus	sp.									1
		Tanypus	sp.									
		Clinotanypus	sp.									
		Unidentified										
(Crayfish)	Astacidae (family)											
Bryozoa		Crystatella	mucedo									

TABLE IV-B-4, Continued

Benthic Organisms of the St. Louis River, 9 July 1975

PHYLA		GENUS	SPECIES	4-A	4-B	4-C	5-A	5-B	5-C	6-A	6-B	6-C
Arthropoda		Gammarus	fasciatus									
		Gammarus	lacustris									
		Gammarus	pseudolimnaeus							5		
		Hyallella	azteca							1	1	
		Pontoporia	affinis									
		Asellus	intermedius					2	6	28		3
		Asellus	racovitzai							1		
		Rheotanytarsus	sp.									
		Tribelas	sp.									
		Cricoptopus	sp.									
		Lauterborniella	sp.									
		Procladius	sp.	24	15	19	1	5	5	9	5	2
		Parachironomus	sp.									
		Cryptochironomus	sp.								2	1
		Chironomus	sp.									
		Polypedilum	sp.									
		Coelotanypus	sp.									
		Potthastia	sp.									
		Paracladopelma										
		Podonominae	sp.									
	Tricoptera	Glossosoma	sp.	1								
	Tricoptera	Phylocentropus	sp.		4							
	Tricoptera	Neureclipis	sp.									
	Tricoptera	Molanna	sp.									
		Leptocella	sp.									
	Insecta	Corixidae Nymph	sp.									
	Insecta	Plecoptera Nymph	sp.									
		Hexagenia	sp.									
		Wormaldia	sp.									
	Cladocera	Eurycercus	sp.									
		Tanypus	sp.									
		Clinotanypus	sp.						1		3	
		Unidentified								1		
(Crayfish)	Astacidae (family)											
Bryozoa		Crystatella	mucedo									

TABLE IV-B-5

Benthic Organisms of the St. Louis River, Summer 1975

PHYLA	GENUS	SPECIES	1-A	1-B	1-C	2-A	2-B	2-C	3-A	3-B	3-C
Bryozoa	Grystatella	mucedo						1			
Nemathelmenthes Nematoda					5	29	29		8		6
Annelida	Helobdella	elongata	2		2		1		1		
	Helobdella	stagnalis			6	18	5		5	5	7
Mollusca	Sphaerium	fabale									
	Sphaerium	lacustre									
	Sphaerium	partumeium								4	
	Sphaerium	securis								4	1
	Sphaerium	transversum								1	
damaged	snails					1					
	Sphaerium	(immature)			3	3	6			14	
	Pisidium	fallax				1				2	
	Valvata	tricarinata	1								
	Helisoma	anceps anceps									
	Promentus	exacuous mega									
	Promentus	umbilicatellus									
	Amnicola	limnosa									
	Ferrissia	rivularis									
	Marstonia	decepta									
	Gyraulus	deflectus									
Arthropoda	Asellus	forbesi									
	Asellus	racovitzai									
	Asellus	sp.				1					
	Asellus	(immature)	19		2		2				
	Gammarus	fasciatus									
	Gammarus	lacustris	5								
	Gammarus	pseudolimnaeus									
	Procladius	sp.			5	4			2	14	1
	Cryptochironomus	sp.					2		2	1	
	Paracladopelma									3	
	Podonominae	sp.									
	Coelotanypus	sp.									
	Glossosoma										
	Phylocentropus	sp.									
	Neureclipsis	sp.							7	3	
damaged	insect				1						
	Polypedilum	sp.				2					
DIVERSITY INDICES (D.I.)			1.86	0.00	5.73	2.91	2.22	1.00	4.26	5.50	2.59

TABLE IV-B-5, Continued

Benthic Organisms of the St. Louis River, Summer 1975

PHYLA	GENUS	SPECIES	4-A	4-B	4-C	5-A	5-B	5-C	6-A	6-B	6-C
Bryozoa	Grystatella	mucedo				14	22	13		6	1
Nemathelmenthes Nematoda						3			4	1	1
Annelida	Helobdella	elongata				1	1	23			
	Helobdella	stagnalis									
Mollusca	Sphaerium	fabale	1		2					1	2
	Sphaerium	lacustre							2		
	Sphaerium	partumeium	1								
	Sphaerium	securis		2	3						
	Sphaerium	transversum		1	1		1				
	damaged	snails							5		
	Sphaerium	(immature)	22	2	7	2			41	5	16
	Pisidium	fallax							21	6	
	Valvata	tricarinata							3	1	1
	Helisoma	anceps anceps								2	
	Promentus	exacuous mega							1		
	Promentus	umbilicatellus							1		
	Amnicola	limnosa	2								
	Ferrissia	rivularis							1		
	Marstonia	decepta	3								
	Gyraulus	deflectus							2		
	Asellus	forbesi							66		
Arthropoda	Asellus	racovitzai				1					
	Asellus	sp.		1							
	Asellus	(immature)							16		
	Gammarus	fasciatus							24		
	Gammarus	lacustris							41		
	Gammarus	pseudolimnaeus				1					
	Procladius	sp.	14	5	14				3	3	3
	Cryptochironomus	sp.		1			1				2
	Paracladopelma										1
	Podonominae	sp.								12	
	Coelotanypus	sp.						1		3	1
	Glossosoma		1								
	Phylocentropus	sp.	10	5							
	Neureclipsis	sp.			1	1			7		1
	damaged	insect									
	Polypedilum	sp.									
DIVERSITY INDICES (D.I.)			3.66	4.74	3.02	2.48	1.28	1.99	6.22	6.02	3.01

TABLE IV-B-6

Benthic Organisms of the St. Louis River, Fall 1975

PHYLA	GENUS	SPECIES	1-A	1-B	1-C	2-A	2-B	2-C	3-A	3-B	3-C
Platyhelminthes											
Turbellaria (class)							1				
Bryozoa	Crystatella	statoblast					4				
Annelida	Helobdella	stagnalis	1	2		2					2
	Helobdella	elongata				10	8				
	unidentified but large unique sp.										
	Valvata	tricarinata									
	Glossiphonia	complanata									
	Sphaerium	simile	1								
Mollusca	Sphaerium	sp.		2			1				
	Sphaerium	striatinum		1							
	Sphaerium	securis				3					
	Sphaerium	fabale									
	Sphaerium	transversum									
	Sphaerium	occidentale									
	Sphaerium	lacustre									
	Sphaerium	partumeium									
	Sphaerium	(immature)									
	Valvata	tricarinata	1								
	Amnicola	limnosa		2							
	Ferrissia	rivularis		5							
	Pisidium	fallax									
	damaged snails				1						
	Chironomus	sp.	1	19							
Arthropoda	Asellus	racovitzai	7								
	Asellus	sp. (immature)		100	12						
	Asellus	sp.								1	
	Glyptotendipes			5							
	Gammarus	fasciatus		19							
	Gammarus	lacustris			5						
	Gammarus	pseudolimnaeus									
	Procladius	sp.				5	4		3	7	8

TABLE IV-B-6, Continued

Benthic Organisms of the St. Louis River, Fall 1975

PHYLA	GENUS	SPECIES	4-A	4-B	4-C	5-A	5-B	5-C	6-A	6-B	6-C
Platyhelminthes											
Turbellaria (class)									5		
Bryozoa	Crystatella	statoblast									
Annelida	Helobdella	stagnalis				3		20			2
	Helobdella	elongata				2		4			
	unidentified but large unique sp.							1			
	Valvata	tricarinata								1	1
	Glossiphonia	complanata									
Mollusca	Sphaerium	simile					1				
	Sphaerium	sp.									
	Sphaerium	striatinum					1				
	Sphaerium	securis									
	Sphaerium	fabale	4								
	Sphaerium	transversum	1								
	Sphaerium	occidentale	1								
	Sphaerium	lacustre						1		1	
	Sphaerium	partumeium									1
	Sphaerium	(immature)	7							2	9
	Valvata	tricarinata									
	Amnicola	limnosa									1
	Ferrissia	rivularis									1
	Pisidium	fallax								1	1
	damaged snails										1
	Chrionomus	sp.									17
Arthropoda	Asellus	racovitzai				1		5			21
	Asellus	sp. (immature)	2	3	1						42
	Asellus	sp.									1
	Glyptotendipes										5
	Gammarus	fasciatus				6					5
	Gammarus	lacustris									4
	Gammarus	pseudolimnaeus									
	Procladius	sp.			2			4		5	14

TABLE IV-B-6, Continued

Benthic Organisms of the St. Louis River, Fall 1975

PHYLA	GENUS	SPECIES	1-A	1-B	1-C	2-A	2-B	2-C	3-A	3-B	3-C
Arthropoda (continued)	Cryptochironomus					1			1	1	
	Potthastia	longimanus									
	Microtendipes										
	Dicrotendipes	nervoses									
	Coelotanypus	sp.									
	Einfeldia	sp.									
	Hyalella	azteca									
Astacidae (family)				1							
Insecta (class) Trichoptera (order)	Neureclipsis	sp.	13	1	3			1	3		2
Insecta (class) Plecoptera (order)	Isoperia	sp.									
Nemathelmenthes Nematoda											
DIVERSITY INDICES (D.I.)			2.59	2.29	2.46	3.17	3.02	1.00	3.52	2.20	3.00

TABLE IV-B-6, Continued

Benthic Organisms of the St. Louis River, Fall 1975

PHYLA	GENUS	SPECIES	4-A	4-B	4-C	5-A	5-B	5-C	6-A	6-B	6-C
Arthropoda (continued)	Cryptochironomus							1		3	5
	Potthastia	longimanus						2		1	
	Microtendipes									1	
	Dicrotendipes	nurvoses								1	
	Coelotenypus	sp.								1	6
	Einfeldia	sp.									1
	Hyalella	azteca									5
Astacidae (family)						1					
Insecta (class) Trichoptera (order)	Neureclipsis	sp.			2						
Insecta (class) Plecoptera (order)	Isoperia	sp.								2	
Nemathelmenthes Nematoda					1	2		13			1
DIVERSITY INDICES (D.I.)			3.17	1.00	3.60	4.09	2.00	4.11	1.00	7.37	6.97